Agriculture Irrigation Polyacrylamide Application Standard

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Irrigation induced erosion has had a significant impact on western water bodies for several years *(Koluvek et. al., 1993; Berg and Carter, 1980; USDA-ARS, 1959)*. Irrigation erosion on surface irrigated fields results in sediment being transported off farm and downstream. Irrigation created suspended sediments has been identified as having a social and economic off site impact on fisheries, hydro generation storage, waterways and transportation facilities *(Koluvek et. al, 1993; Carter 1990)*. In addition, the loss of topsoil from surface irrigation erosion has been documented to decrease crop yield*(Carter et. al., 1985)*.

In 1991, the United State Department of Agriculture, Agricultural Research Service (USDA-ARS) Northwest Irrigation and Soils Research Laboratory at Kimberly, Idaho, measured extraordinary erosion and sediment yield reductions from surface irrigated fields with the application of polyacrylamide (PAM) materials *(Sojka and Lentz, 1994)*. These benefits, plus the relatively low treatment cost, have been recognized by the agricultural community, resulting in rapid adoption.

The attraction to polyacrylamide has been the low seasonal material, equipment and labor costs. These low costs have made PAM an economical alternative to historic practices used to control furrow erosion. Practices available that approach the levels of sediment reduction from PAM included furrow mulching and furrow stream cutback. Both of these practices are labor intensive.

In 1994, the USDA - Natural Resources Conservation Service (USDA-NRCS), working with the Kimberly ARS station, developed a West National Technical Center (WNTC) conservation practice standard for polyacrylamide application. The standard incorporates current research and is designed to accomplish safe application of polyacrylamide materials.

Environmental concerns have been expressed on the downstream effects of polyacylamide materials in surface waters. Additional research is ongoing at ARS Kimberly to address the concerns.

NRCS Conservation Practice Standards

Conservation Practice Standards are based on research, conservation field trials and accumulated knowledge and experience. Input and comments from research, manufactures, dealers, farm organizations and operators are frequently utilized during development or revision of standards. Standards are revised periodically to incorporate new information and state-of-the-art technology.

The NRCS uses conservation practice standards to establish the minimum level of acceptable quality for planning, designing, installing, operating and maintaining conservation practices. Conservation practice standards are also used to transfer and apply current or new technology.

Individual Practice Standards are a component of an overall resource or conservation management system. Used with companion standards, they establish the acceptable level of quality for planning, designing, applying, operating, and maintaining a conservation system.

The NRCS has developed a standard structure for consistency of it s conservation practice standards *(USDA-SCS, 1992; USDA-SCS, 1990)*.

Each practice is composed of eight sections. The sections and descriptions are as follows: **Definition** — describes the practice. **Purpose** — identifies the primary reasons for which the practice applies and the resource problems it is intended to address. **Conditions Where Practice Applies** — identifies the suitability to various land uses and or site conditions.

Criteria — provides the meat of the practice standard. This section includes the limits for design parameters or materials, acceptable application or installation processes, and any performance requirements. **Considerations** — lists recommendations or elements that might need to be addressed or modified with the application of the practice. Where safety and health is a potential issue, a safety and health statement is generally presented.

Plan and Specifications — aids in the preparation and presentation of materials and information, based on the standard, for the application to a specific site or field location. An example of a PAM site specification is shown in Exhibit 2. Standards that have identified elements requiring repetitive actions, to assure proper performance, contain an **Operation and Maintenance** — identifies elements requiring repetitive actions to assure proper performance of the practice. A reference section may be added by states to incorporate a list of publications helpful in planning or implementation of the practice.

A main advantage of practice standards is that they provide criteria that becomes a base level of acceptable quality. Without standards, everyone would develop their own ideas concerning acceptable and unacceptable applications or installations. Standards provide flexibility to allow for development of site specific criteria and establish levels to monitor and evaluate the success or improvement of the practice. If deficiencies are found, the standard is revised.

To address new and rapid advancing technology, such as the use of polyacrylamide to control furrow erosion, interim standards are often developed. Interim standards allow for up to three years to assess and modify criteria prior to formal adoption of the practice by the NRCS.

Practice standards are not developed to target or preclude specific manufactures materials. They are developed generically to provide the opportunity for any manufacture's applicable materials to qualify in meeting practice criteria. Criteria placed on materials in a standard are the result of research, laws and regulations, and historic assessment. The criteria and/or limits established within a standard assure the end user that material conforming to the standard will provide a practice that functions as intended.

Rationale NRCS Interim Standard - Irrigation Erosion Control (Polyacrylamide-PAM)

Exhibit 1 is an NRCS interim practice standard addressing the control of furrow irrigation erosion using polyacrylamide. Development of the interim standard was initiated in 1994 by staff at the former Soil Conservation Service, West National Technical Center in Portland, Oregon. During development, input was solicited and received from ARS, industry and various NRCS western states. Prior to it's release in January of 1995, final review and comments were provided by Dr. Robert E. Sojka and Dr. Rodrick D. Lentz of the USDA-ARS, Northwest Irrigation and Soils Research Laboratory at Kimberly, Idaho.

The technology for practical and economic treatment of surface irrigation induced erosion was the result of research of PAM use in surface irrigation waters of southern Idaho (ARS - Kimberly) and other locations since 1991. Kimberly research information and literature indicated a significant reduction in field erosion and sediment yield. Reductions of 80-99% sediment yield were the norm when applying 10 ppm PAM concentration during the advance phase of furrow irrigation. No polyacrylamide applications were needed during the balance of the irrigation. Applications in excess of 10 ppm were shown to be non beneficial from research. A limit of 10 ppm was selected as standard criteria.

Historic studies on furrow irrigation have documented that the highest sediment yield occurs during the first few hours of the first irrigation, on unconsolidated or disturbed soil surfaces *(Carter, 1990)*. Research documented that the introduction of PAM during the irrigation advance stage bonded the surface soil particles, resulting in furrow shape retention and reduced soil erosion *(Sojka and Lentz, 1994)*. Research and field experience indicates that residual effects of PAM diminishes with time, however the majority of effectiveness is retained until soil surface disturbance occurs. The residual influence or loss thereof was addressed in the criteria section of the standard.

Based on applications ranging from 0 to 20 ppm, research indicates that the optimal PAM concentration appears to be 10 ppm. Kimberly ARS research indicates that PAM premixed and agitated into stock solutions provides the most consistent and uniform concentrations. Dry applications, requiring more vigorous mixing, provides similar treatment levels, however resulted in higher amounts of PAM transport off the field in tailwater. This off field effect with dry PAM was reduced when PAM was introduced and mixed in turbulent water. The standard does not preclude any means of introducing PAM to the irrigation waters, as long as label and manufactures instructions are followed.

Various effects and impacts to the soil and water resource from use of PAM material are still being questioned. While no negative effects have surfaced from industry use, questions arise concerning the effects of PAM that leaves the field with tailwater. Research indicates that applications during the advance stream phase resulted in minimal concentrations of PAM in the runoff waters. To minimize material runoff concerns, this advance phase application criteria has been placed in the standard

Anionic (negatively charged) forms of polyacrylamide has an extensive history of use as a flocculent in: the food processing industry; food packaging industry; off shore oil drilling; and municipal drinking water and sewer facilities. No environmental issues have surfaced with anionic material use. Use as an irrigation erosion and sediment flocculent have not been addressed, however logic leads us to assume that industry environmental results appear applicable. Downstream influences and reuse were addressed in the considerations section of the Standard.

An environmental issue raised during development and review of the interim standard was the monomer concentration of the polyacrylamide (*EPA, personal communications*). EPA drinking water standards address a 0.05% monomer maximum concentration. All commercially available materials presently used in furrow erosion treatment meet this guideline. The monomer limit was included as a criteria component in the standard.

Polyacrylamide is available in both anionic and cationic forms. Both are commonly available and meet FDA and EPA requirements, for specified uses. Research evaluations were conducted using the anionic form of polyacylamide. The anionic form is the only form addressed by the interim standard.

Summary

Polyacylamide has proven effective in the control and reduction of sediment yield from furrow irrigated fields. The interim NRCS standard provides criteria and guidance in the use and application of the material to minimize off-site concerns. The off-site effects of PAM on aquatic habitat and waterways is not fully researched and understood.

Evaluation of any potential impacts or effects of off-site polyacylamide transport should not be judged solely by itself. Total evaluation needs to consider the resource impact created by the removal or the previously present sediment loads. Evaluations of the pros and cons of using polyacrylamide needs to include the impact of nutrients, pesticides, and organic materials transported with the sediment which previously entering the streams and water bodies of concern.

Intuitively, the use of polyacrylamide appears more environmentally friendly. Specialists and environmental concerns need to become fully aware of the surface irrigation polyacrylamide practice and effects to gain the fullest acceptance and use.

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Exhibit 3

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Guide to Polyacrylamide (PAM) Use for Erosion Control by Tim D. Stieber, University of Idaho - Extension Educator, Unpublished 1994.

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Interactions of Certain Polyacrylamides with Soil Bacteria by Mary M. Grula, May-Lin Huang, and Guy Sewell, Soil Science, pg. 291-300, Vol. 158, No. 4, October 1994.

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NATURAL RESOURCES CONSERVATION SERVICE
INTERIM CONSERVATION PRACTICE STANDARD

IRRIGATION EROSION CONTROL (POLYACRYLAMIDE)

(acre)
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DEFINITION

The addition of polyacrylamide to irrigation water.

PURPOSE

To minimize or control irrigation-induced soil erosion.

CONDITIONS WHERE PRACTICE APPLIES

On corrugation or furrow irrigated lands susceptible to irrigation-induced erosion. This practice does not apply to peat soils or where irrigation waters exceed a sodium adsorption ratio (SAR) of 15.

CRITERIA

The polyacrylamide (PAM) will be of the anionic type meeting EPA and FDA Acrylamide monomer limits of 0.05%, have a charge density of 0 to 35% and a molecular weight of 6 to 15 mg/mole. It shall be applied according to the labeling of the product for this use. Use shall conform to all federal, state, and local laws, rules, and regulations.

PAM will be used during the first irrigation after soil disturbance (pre-irrigation is considered irrigation).

PAM will be added to irrigation water only during the advance phase of an irrigation. The advance phase will be considered to be from the time irrigation starts until water has advanced to the end of the furrows or corrugations.

The concentration of PAM in irrigation water applied shall not exceed 10 ppm. Mixing of and/or application of materials shall be in accordance with the manufacturers recommendations.

CONSIDERATIONS

Other conservation treatments such as land leveling, irrigation water management, reduced tillage, crop rotations, etc. should be used in conjunction with this practice to control irrigation-induce erosion.

Adjustment of the concentrations downward from 10 ppm may be used so long as no visible erosion occurs.

Secondary applications on untilled furrows may be needed but may not require as high a rate as the first application.

Where reasonably possible, the tailwater containing PAM should be used on other fields (or stored for a future irrigation).

PAM is a flocculating agent which can cause deposition in canals, laterals, head ditches, pipelines, furrows, or other locations where it comes in contact with sediment laden waters. Down stream deposition from the use of PAM may require frequent cleaning to maintain normal functions.

The advance rate can vary greatly between hard rows (wheel packed) and soft rows. Both PAM application and irrigation water management would benefit from treating these differences appropriately.

Consider the impacts of increases in infiltration of up to approximately 15% when PAM is applied.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

SAFETY AND HEALTH

Consider proper health and safety precautions according to the label and industry guidelines. If inhaled in large quantities, PAM dust can cause choking and difficult breathing. A dust mask of a type recommended by the manufacturer should be used by persons handling and mixing PAM. PAM solutions can cause surfaces, tools, etc. to become very slippery when wet.

PLANS AND SPECIFICATIONS

Specifications will be developed site specifically for each application. Specifications for this practice will be prepared for each field or treatment unit according to the criteria, considerations, and operation and maintenance described in this standard. Specifications shall be recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

OPERATION AND MAINTENANCE

Irrigations will be monitored and the PAM applications to irrigation waters will be discontinued when the advance phase has been completed.

All equipment will be operated and maintained to provide the uniform application rates as listed in Criteria. Rinse all equipment used to mix and apply PAM thoroughly with water to avoid formation of intractable PAM residues.

EXHIBIT 2

PAM Furrow Irrigation
SITE APPLICATION SPECIFICATION

MATERIAL

The polyacylamide used for reducing surface irrigation erosion shall meet the following requirements:

* Monomer maximum concentration of 0.05%
* Anionic form (negatively charged)
* Charge density of 0 to 35%
* Molecular weight of 6 to 15 mg/mole

POLYMER APPLICATION

Maximum application rate shall be a 10 ppm.

Application shall occur only during the advance phase of surface irrigation.

FURROW STREAM SIZE

Irrigation infiltration is generally increase with the application of polyacylamide by 15% or greater. Stream sizes may need to be modified to assure reasonable advance times.

With larger stream sizes and increased infiltration, set times may need to be modified to reduce volumes of deep percolation.

Where stream sizes have been restricted due to excess movement and erosion of soil, this restriction is removed. This will allow for improved efficiency with a change in water application and management.

SITE CRITERIA

Present Advance Time ____________ (hours)

Present Field Flow ____________ (cfs)
(1 cfs = 450 gpm)

Polymer Required ____________ (lb./set)

GENERAL RECOMMENDATIONS

- Follow a recommended irrigation water management plan.
- For the most uniform water application, advance streams containing polyacylamide should reach the end of the field in the first 20 to 35 percent of the total set time.
- Follow the products label instructions, paying particular attention to element of safety and health. The dry form is a dust health hazard.
- Use polyacrylamide on the each irrigation that follows a soil disturbance operation, particularly the first irrigation of the season. Reapply the polymer to an irrigation when soil movement is noted.
- Based upon soils, slope, and stream size, the necessary concentration of polyacrylamide may be reduced. For the best and most economic concentration, back off on the amount of polymer used until soil movement is noted, then increase slightly.
- Sound turbulent mixing of the polymer is critical. Lack of adequate turbulence is generally indicated by jellying and deposition of polymer material downstream of the application point.

OTHER COMMENTS

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NRCS, WNTC
JAN, 1995